5-2020

Disentanglement in a Contested Setting: Testing the Effects of Cultural Reminders on Kahan et al.'s Geoengineering Result

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Testing the Effects of Cultural Reminders on Kahan et al.'s

Geoengineering Result

A thesis submitted to the Environmental

Science and Policy Program at The College of William and Mary

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The Science Communication Paradox and (Failed) Consensus Messaging

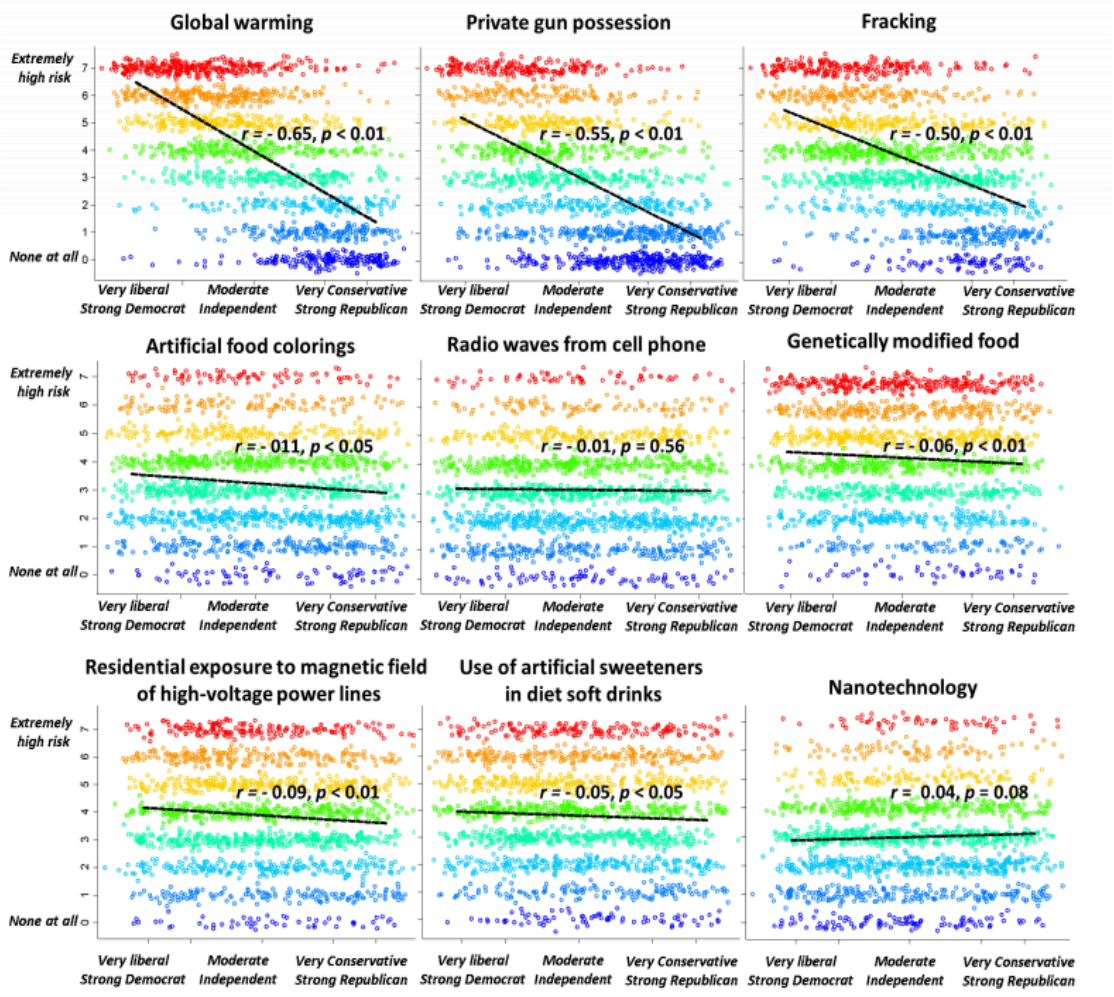
The gap between scientific understanding and public perception of climate change remains at the forefront of science communication research. As of March 2018, The Yale Program on Climate Change Communication found that only 58% of Americans believe climate change is human caused—the same level as in 2009. In contrast, over 97% of climate scientists recognize anthropogenic climate change (Cook et al. 2013, Leiserowitz et al. 2014). There is good news. Despite persistently low acceptance of climate change science among certain populations, public belief levels have recovered since a staggering 14% drop in 2010 (Leiserowitz et al. 2018). To avoid unwarranted pessimism or optimism, this paper will simply echo a common summary: scientists are more sure of the severity and imminence of anthropogenic climate change than ever before, meanwhile, the public remains persistently divided along partisan and religious lines[1]. Kahan identifies several issues—including fracking, gun possession, and climate change—in which public perception diverges from expert understanding. He calls this phenomenon the *science communication paradox*.

Climate change communication orthodoxy has long been that *consensus messaging* (relaying expert consensus to the public) is the best method to educate the public on climate change and overcome the science communication paradox. First promoted by the International Panel on Climate Change (IPCC) in 1995, the strategy has received the lion's share of climate change communication resources over the last two decades (Kahan 2015). Practitioners of consensus messaging rely on a wealth of studies showing that scientists overwhelmingly agree that climate change exists and is largely anthropogenic (Oresk 2004, Cook et al. 2013, Leiserowitz 2014). Additional research empirically argues in favor of consensus messaging, showing that educating

[1] Figure 1 shows how perceived risk of several issues correlates strongly with political affiliation/cultural worldview. For these issues, Kahan argues that people are relying on cues other than scientific understanding to form opinions (2015). Note that for most scientific issues, this is not the case. It is only for a select few issues in which technical topics accrue cultural significance that certain groups believe differently than scientific consensus.

people about scientific consensus increases climate change belief (McCright et al. 2013, van der Linden et al. 2014, Cook and Lewandowsky 2016).

Figure 1: "Polarized" vs. "unpolarized" risk perceptions (Kahan 2015)



Despite its many proponents, consensus messaging has faced increased scrutiny in recent years. As Russill noted in 2018, "proposals to reshape [climate change communication] usual practices have proliferated rapidly and sharpened differences among experts regarding the nature and purposes of public communication on climate change" (1). Such proposals are motivated by a

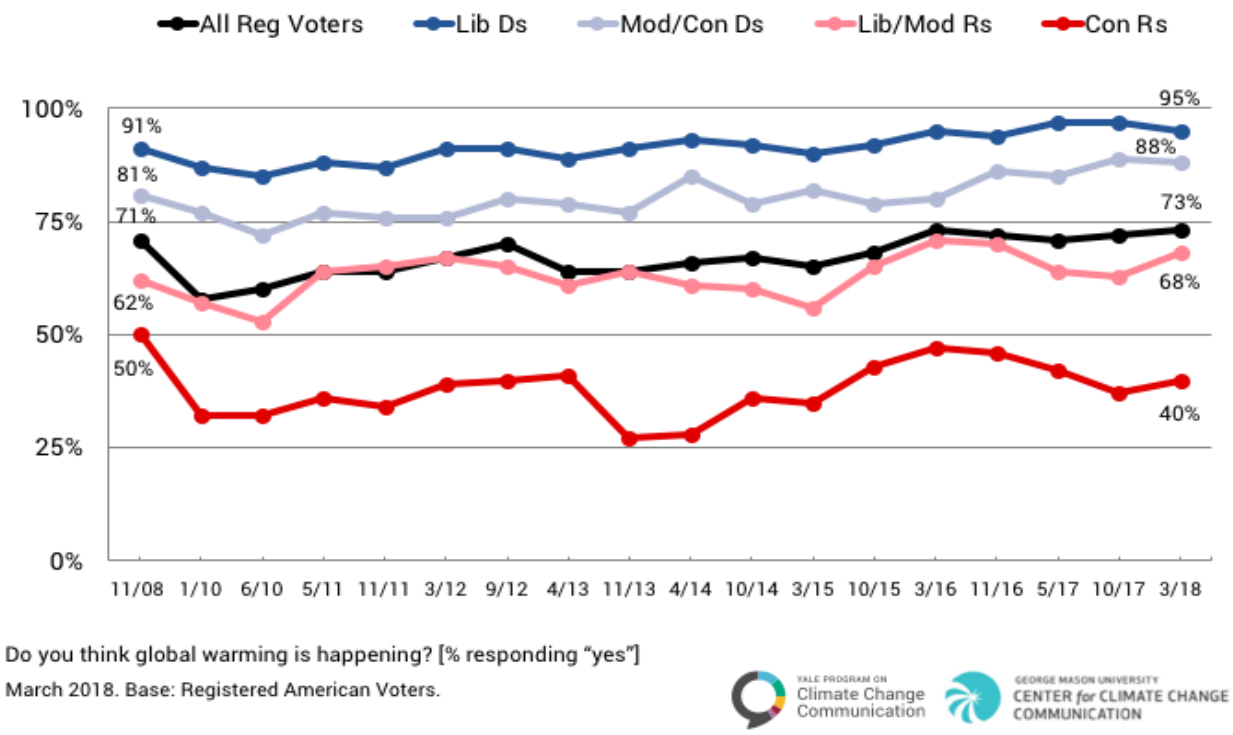
simple observation: climate change communicators have relied on consensus messaging for over two decades, yet climate change belief has not increased meaningfully since the early 2000s[2].

In their 2015 paper *Geoengineering and Climate Science: Testing a Two Channel Model of Science Communication,* Kahan et al. argue that the failure of consensus messaging lies in its inability to increase belief among people with conservative values (see next section). Polling data by Yale's Program on Climate Change Communication supports this interpretation (see figure 2). First, note that public belief has slowly recovered since falling between 2008 and 2010. Although during that period of declining belief there was a slight decrease among liberal democrats, accompanied by a slightly greater decrease among moderate and conservative democrats, it is clear that the dramatic 20% drop among conservative Republicans and 10% drop among liberal and moderate Republicans accounts for most of the decline in overall levels. Furthermore, note the belief among democrats has remained largely stable since 2011, while trends in overall public belief (i.e. another dip from 2012 to 2013 followed by a gradual increase) have corresponded with more pronounced fluctuation in Republican belief levels. In total, there has been a 10% among conservative republicans since 2008, balanced out by slight increases in every other group.

It follows that reducing the gap between scientific consensus and public belief lies primarily in increasing belief among conservatives. The fact that "about 75% of 'conservatives'… know that scientists believe CO2 emissions increase atmospheric temperatures... yet only *25%* of them say they 'believe in' human-caused climate change" suggests that consensus messaging is reaching conservatives but failing to convince them (Kahan 2015). In other words, the science communication paradox is not driven by lack of exposure to scientific information; instead, there are dynamics related to an individual's cultural identity affecting climate change belief.

[2] In their 2017 meta-analysis of climate change communication research, Egan and Mullin similarly find that "polling data about Americans' attitudes on climate change reveals a lack of meaningful long-term change in mass opinion" (2017).

Figure 2: American climate change belief over time (Leiserowitz et al. 2018)



solution, Kahan argues, is to examine how scientific issues accrue social and cultural significance in order to develop more effective communication strategies (2015). In the next section, I review Kahan's explanation of what causes the science communication paradox and critically discuss his framework for overcoming it.

Cultural Cognition and the Disentanglement Principle

Emphasizing the impact of cultural commitments in risk perception and belief formation, Kahan's *Cultural Cognition Thesis* offers a compelling explanation for the widely acknowledged *Science Communication Paradox* (Kahan et al. 2010, Kahan 2015). Kahan suggests that people have two channels for processing information: knowledge and culture. Being "cognitively prior"

to knowledge, the cultural channel both colors how we perceive factual information and influences which information we expose ourselves to. In terms of risk assessment, this means that "groups of individuals will credit and dismiss evidence of risk in patterns that reflect and reinforce their distinctive understandings of how society should be organized" (Kahan 2015, 194).

That culture is cognitively prior to information has little impact on the majority of scientific issues which are not imbued with cultural baggage; however, when inherently scientific issues (i.e. climate change) accrue cultural significance independent of expert consensus, individuals struggle to separate positions held by their group from facts. Consequently, conflicting cultural and scientific representations generate cognitive dissonance—dissonance that is often resolved by rationalizing views that contradict scientific consensus. This is why more/better information rarely changes opinions.

Illustrated by studies indicating that certain issues engender greater social polarization as scientific literacy increases (Kahan et al 2012, Drummond and Fischoff 2017), cultural cognition denies that individuals are inherently rational or irrational. Unscientific positions are certainly irrational and obstruct progress yet holding such views may be considered rational for the individual since they reinforce group membership and identity. People employ motivated reasoning to justify opinions which align themselves most closely with what they are predisposed to believe (Khanna and Sood 2018, Kunda 1990). According to Kahan, these predispositions are cultural and scientifically literate individuals polarize because they are better equipped for such rationalization. Drummond and Fischoff suggest that increased polarization among more scientifically literate individuals "may reflect greater knowledge of when issues have divided along identity lines, greater ability to defend such beliefs, or greater confidence in one's own knowledge". Even Sunstein, a critique of the cultural cognition thesis, argued similarly in 2001

that individuals adopt polarized group views in part due to "people's desire to maintain their reputation and their self-conception."

Assuming the cultural cognition framework is valid, and the science communication paradox arises from conflicting factual and cultural representations of issues, the proscribed solution is to *disentangle* the question "what do we know" from the question "whose side are you on" (Kahan 2015). As Roos suggests, scientific issues become contested in public discourse "[w]hen more than one set of heuristics for judging the accuracy, legitimacy, and value of certain knowledge applies" (i.e. a religious vs. scientific framework for creation) (Roos 2017). This mirrors Kahan's belief that the fundamental source of the paradox is the entanglement of opposing factual beliefs with people's identities as members of one or another cultural group. Thus, when conflicts between identity and science arise, the best way to communicate relevant information to individuals and communities is to disentangle knowledge and identity. But despite its relative prominence, many questions surround the different calls for what Kahan labels 'disentanglement'. Most significantly, how is this done? And does it effectively address the shortcomings of consensus messaging and other approaches?

Kahan et al. (2015) took an important step in tackling the first question. Their paper hypothesizes that as individuals engage knowledge and cultural channels when processing information, "empirical claims about societal risk become suffused with antagonistic cultural meanings". To test this hypothesis, the researchers fielded an experimental survey in which recipients were primed with different news stories appealing to various cultural values: a geoengineering article suggesting climate change mitigation coincides with innovation and industry, an anti-pollution article emphasizing egalitarian pollution control in industrialized countries, and an unrelated control article. Afterwards, respondents read all reading and assess a strictly factual climate change article.

Subjects also completed a question battery measuring where they fell on two values spectrums: hierarchical to egalitarian versus individualistic versus communitarian. Kahan argues that these values (also referred to as 'worldviews') have special bearing on the topic of climate change. He explains, "individualistic values can be expected to be relatively dismissive of environmental and technological risks, which if widely accepted would justify restricting commerce and industry... The same goes for individuals with hierarchical values, who see assertions of environmental risk as indictments of social elites. Individuals with egalitarian and communitarian values, in contrast, see commerce and industry as sources of unjust disparity and symbols of noxious self-seeking" (Kahan 2015, page 194; Douglas and Wildavsky 1982).

Kahan found that individuals who measured more hierarchical and individualistic were slightly more concerned about climate change when treated with geoengineering versus the control and significantly more concerned when treated with geoengineering versus anti-pollution. The difference between treatment groups suggests that being primed with information consistent with your value set (and in turn cultural identity) will influence your interaction with the 'knowledge channel'. Hierarchical-individualists treated with the geoengineering article were led to believe human enterprise and ingenuity can solve climate change—aligning climate change responses with their value set and reducing combative cultural connotations, like egalitarian attacks on the status-quo. In turn, they were better at assessing information presented by factual scientific articles and less skeptical of author bias.

The idea that effective communication requires navigating cultural and political group identities is by no means exclusive to the body of work comprising cultural cognition (Gastil et al. 2005; Graham et al. 2009; Hamilton et al. 2012; Jaspal et al. 2013; Kaplan et al. 2016; Feinberg and Willer 2015). For example, in the same year Kahan et al. published their geoengineering study, Feinberg and Willer advocated for "political persuasion that, rather than challenging one's moral

values, incorporates them into the argument." In 2012, Hamilton et al. similarly noted that communicators should be aware that "strongly ideological respondents acquire information selectively in ways that reinforce their existing beliefs." Also in 2012, Haidt likened the human mind to a rider and an elephant plotting a course—the rider (comparable to Kahan's knowledge channel) has a minor correctional influence, while the elephant (the culture channel plus other biases) decides the overall direction. These scholars all agree when it comes to communicating important information, simply disseminating knowledge is *not* enough. Furthermore, all recognize that the ideological predispositions held by culturally defined individuals will not erode under barrages of credible evidence; rather, polarized narratives (credible or not) must instead be reframed, and information repackaged, to circumvent antagonistic cultural meanings and co-opt potentially constructive cultural values.

On closer examination, it is clear that many of the different frameworks for approaches are largely the same. For example, in 'disentangling' knowledge from identity, Kahan uses geoengineering to 'incorporate' certain 'values' in people's perception of climate change mitigation. Meanwhile, Feinberg and Willer and Hamilten et al. seemingly advocate for strategies that reduce what Kahan would call "antagonistic cultural meanings". This overlap is indicative of some convergence in the study of culturally/morally informed communication. Kahan et al. noted over a decade ago that "a growing body of work suggests that cultural worldviews permeate all of the mechanisms through which individuals apprehend risk" (2006). Interestingly, as the authors of this paper have observed, most researchers who discuss cultural communication in one form or another understate similarities between their frameworks and those of other researchers. In the interest of simplicity, this paper adopts the terminology of Kahan's cultural cognition thesis.

Criticisms and Unresolved Questions

Despite its apparent advantages, cultural cognition is not without its flaws. It is worth mentioning that Kahan's relatively broad thesis is grounded in exclusively Western-oriented research on a specific set of phenomena, calling into question the scope of its application. Furthermore, Kahan lacks specificity and fails to define important terms like "culture" and "cognition" in his work (van der Linden 2016). Both lines of criticism have important implications when it comes to applying disentanglement strategies, both in the United States and abroad.

Another criticism of Kahan et al.'s geoengineering study is the unclear relation between values/worldview and group identity. Recall the lack of a precise definition of culture. Intuitively, culture could refer to an individual's values, as well as their group commitments. In a general sense, culture is most likely a combination of values, group identity, and a host of other factors. However, whether disentanglement interacts more with values or group identity (in this case political affiliation) has bearing on the real-world applications of the disentanglement strategies. Kahan's choice to sort respondents according to values scales, and not political affiliation, clearly shows that he thinks values are the stronger factor. This is not necessarily the case. It could be the case that people are actually adopting climate change stances following cues from their political in-group, and not necessarily their values. Citing research about 'partisan motivated reasoning' and people's reliance on identity cues when assessing climate change information (Bolsen, Druckman, and Cook, 2013; Hart and Nisbet, 2012), van der Linden echoes the concern that Kahan et al. may actually be appealing to group commitments more so than an individual's values (2016). I attempt to resolve this debate in this paper's experimental survey.

Another unanswered, but crucial question when it comes to applying the disentanglement principle, is how durable we can expect the disentanglement result to be? To determine how we might go about finding an answer, let us start with a critical examination of the mechanics behind

disentanglement and the findings from Kahan et al.'s geoengineering paper. First, note that Kahan refines his description of the disentanglement mechanic from his initial paper reporting the geoengineering experiment to his subsequent paper *What is the 'science of science communication'?* In fact, the term 'disentanglement' does even not appear in the geoengineering paper. Regardless, both papers offer similar, and overall consistent, descriptions of how geoengineering information interacts with the two channels in the cultural cognition model. The experimental paper says that "[the geoengineering article] transmits, via Channel 2 (knowledge), meanings that offset the pressure on people to dismiss the information content being transmitted via Channel 1 (culture)" (Kahan 2015, page 200). The subsequent paper similarly states that "the information on geoengineering dissolved the conflict those individuals experienced between crediting human-caused global warming and forming stances that express their defining commitments" (Kahan 2015, page 8).

Both descriptions emphasize reducing dissonance between culture and the logical implications of specific knowledge. The objective *is not* to change what message people receive from Channel 2 to make them more likely to trust climate science due to their cultural perspective. Instead, it is to reduce the cultural channel's prominence when individuals interact with climate change information.

It is unclear whether Kahan's experiment actually demonstrates that the knowledge and culture channels are being disentangled. For example, in the geoengineering experiment it might not be the case that the culture channel is not offset in the geoengineering group. Subjects might be relying just as heavily on their cultural channel but are convinced in that moment that their group identity/values align more with the specific piece of information being presented. If this is the case and individuals are not actually engaging more with their knowledge channel, then we might expect the effect to be less durable. In the long run, without being anchored in their own

critical assessment of information, subjects' views will quickly revert to their in-group's entrenched position[3].

Now, let us assume that the geoengineering article did offset the culture channel and subjects engaged with the scientific article more objectively. It is unclear whether this effect will remain if science communicators use disentanglement strategies in settings where people are exposed to reminders of their cultural positions. This is important given the widespread practice of 'false media balancing'—the tendency of media news outlets to present climate science in tandem with climate skeptics. (Boykoff and Boykoff 2004; Dixon and Clark 2013). This misleading representation of climate change as a disputed issue decreases just about every metric of climate change support (Malka et al. 2009). Furthermore, this illusion of contested knowledge "can lead to a negative assessment of the opposed sphere spilling over into uncontested areas of knowledge," which leads to climate change becoming a symbol of outside cultural disputes (Roos 2017, page 6). In practice, the result is that climate change communicators relying on facts are often forced to compete against skeptics relaying cultural positions. If it turns out that efforts to disentangle the culture and knowledge channel are completely undone if audiences are reminded of cultural positions at the same time, the potential applications of disentanglement would be severely limited. If, on the other hand, the effect remains despite the presence of cultural reminders, then disentanglement may be a durable, broadly applicable communication strategy.

Thesis

Kahan et al. found that the geoengineering article reduced the role of the culture channel in processing climate change information. To test the durability of this effect, I inserted paragraphs reminders for liberal and conservative cultural positions as treatment levels and used the original

[3] Kahan et al. call for more research into the long-term effect of disentanglement, as well (2015).

geoengineering article as the control. Unlike Kahan et al.'s nationally representative samples from the United States and the United Kingdom, I restricted the study to just self-identified U.S. Republicans. I then measured respondents' assessment of the same scientific article from Kahan et al.'s study using same *study validity* and *climate change belief* question batteries. The first measure, *study validity*, is a combined score of four questions asking how credible respondents found the scientists and to what degree their results should inform public decision making. The second measure, *climate change risk*, similarly consisted of four questions asking whether climate change is real and is anthropogenic, as well as how much risk it poses.

If the geoengineering article increases objective assessment of climate change information by offsetting the culture channel, then any increased reliance on the culture channel should decrease the disentangling effect. That is, it should not matter which cultural reminders subjects are exposed to—what matters is that subjects are reminded that climate change is a culturally charged issue and that different positions express different group commitments. Between the conservative and liberal reminder treatments, nothing in the theory suggests that one will inherently impede disentanglement more than the other. Since the conservative reminder appeals directly to the hierarchical-egalitarian worldview, it would not be surprising if it impeded disentanglement more. The liberal reminder, on the other hand, could engender some sort of factional reaction and thereby reinforce the tendency to reject information counter to the conservative position. As a result, I suspect that subjects in all treatment conditions will report lower *study validity* and *climate change risk* than the control. Respondents who receive both the liberal and conservative reminder should be the most conscious of cultural positions, and therefore will report the lowest *study validity* and *climate change risk* of all the groups.

H1a: Respondents receiving any treatment will decrease their self-reported study validity or climate change risk compared to control.

H1b: Respondents who are given both reminders will report the lowest levels of study validity and climate change risk.

Although Kahan et al.'s treatments had no meaningful main effect on *study validity* and *climate change risk*, they found significant interaction between the experimental manipulation and subjects' cultural worldviews. In particular, respondents with conservative values (more hierarchical and individualist) reported significantly higher *study validity* when given the geoengineering article. Hierarchical respondents also reported significantly higher *climate change risk* in the geoengineering treatment than in the anti-pollution treatment, even if there was no significant difference between geoengineering and the control.

We should anticipate a similar interaction between worldview and the treatment manipulations. Recall, however, the discussion on cultural worldview versus group identity. By sorting subjects according to values and group identity (in this case political affiliation), the authors of the geoengineering study suggest that values, more so than political affiliation, influences how individuals pick their cultural positions. But these worldview scales could merely be good analogues for political affiliation. This debate can be resolved by comparing the significance and effect size of the treatments conditioned by political affiliation (how strongly respondents identify with the Republican party) versus the worldview scales. It should be the case that group membership will interact more strongly with the treatments that values/worldview scales, i.e. there will be a larger effect size and higher significance for treatment effect on the dependent variables when conditioned by political affiliation.

H2: The effect of the treatment will be conditioned more by self-reported partisanship than by worldview.

Another important finding of Kahan et al.'s paper was the reduced polarization between the hierarchical-individualists and individual-communitarians. It is worth considering how this

effect might translate to a sample of only Republicans. That is, will the cultural reminder treatments still affect hierarchical and individualist subjects differently than more egalitarian and communitarian ones. If the disentangling effect is completely offset among more hierarchical and individualist respondents who are treated with cultural reminders, it might be the case that only Republicans who are already egalitarian or communitarian should be the focus of disentanglement efforts. If, on the other hand, there is not a significant gap between the two ends of the spectrum, then maybe disentanglement is viable for more than a set of 'low-hanging fruit' (i.e. Republicans who have more 'liberal' values). Unlike in Kahan et al.'s sample containing the full political spectrum, it seems unlikely that we will see a similar trend towards convergence of the ends of each value scale (assuming there is a meaningful difference between them to begin with). Instead, I suspect that both respondents who are more hierarchical/individualist *and* those who are more egalitarian/communitarian will report higher *study validity* and *climate change risk* in the control group than in the treatments.

> *H3a: Both hierarchical/individuals and egalitarian/communitarian respondents will report higher study validity and climate change risk in the control than in the treatment groups.*
>
> *H3b: The effect of the treatments will be larger for hierarchical/individualists*

Methodology

Sample:

The sample consists of 1,180 nationally representative Republicans from the United States. Respondents fitting this criterion were identified by the Lucid survey company, and the experiment included questions confirming their political affiliation. I further measured respondents along

Kahan's the two value scales (hierarchical-egalitarian and individual-communitarian) and a question on party affiliation, as a check on Lucid's reported data.

Appropriating Kahan's Geoengineering Treatment:

To quickly recap, Kahan had respondents read two selections. Respondents were first given one of three news articles to read. One of these articles was a piece about geoengineering that *disentangled* respondent's cultural and knowledge channels. The second selection was an excerpt from an article published in the journal *Nature Science*. That article, a composite of real pieces published in *Nature* (Allen et al. 2009) and the *Proceedings of the National Academy of Sciences* (Solomon et al. 2009), suggested that the effects of greenhouse gas emissions might be more severe than originally thought.

I use Kahan's geoengineering article as the baseline condition (see figure 23. For the treatments, I inserted paragraphs into the geoengineering article voicing the perspective of either an environmental advocate, a conservative senator, or both. These paragraphs are intended to remind the reader of the cultural dimension of climate change as a contested issue in the public in the midst of the very cue that should be disentangling them. Respondents were randomly assigned one of four groups and asked to read a news article. They either received Kahan's unaltered geoengineering article (the control), Kahan's article with an inserted liberal reminder, Kahan's article with an inserted conservative reminder, or Kahan's article with both a liberal and conservative reminder.

The liberal reminder paragraph contained arguments by a fictitious environmental advocate calling for greater contributions from developed nations. It draws inspiration from Kahan's 'Antipollution Condition' treatment (the counterpart to the geoengineering article in Kahan's study). The conservative reminder presented fabricated quotes from Alabama Senator Richard Shelby questioning the validity and motives of a report mentioned in the article.

Figure 3: Kahan et al.'s geoengineering article (2015)

Scientists: More Technology, Not More Limits, Needed to Fight Climate Change

New study finds proposed CO2 limits will be ineffective

By Andrew Taylor
May 2018

WASHINGTON, D.C. Staving off the catastrophic effects of global warming will require industrialized countries to shift emphasis from anti-pollution regulation to new technologies aimed at counteracting the effects of climate change, a group of expert scientists announced today.

The group, the American Academy of Geophysical Scientists, based this conclusion on a new study finding the environmental impact of human carbon dioxide is likely to be significantly more severe than previously estimated.

The study was done by researchers from the Massachusetts Institute of Technology who were unaffiliated with the AAGS and who published their findings earlier this year in the journal *Nature Science*.

"Before this study," said AAGS spokesman Dr. Alan M. Williams of Harvard University, "the scientific community assumed it would be enough to gradually slow down and then stabilize CO2 emissions at 450-600 parts per million," a target approved by the United Nations in 2006. "But the data and computer models published by the research team in *Nature Science* show that this strategy will be completely ineffective." Dr. Williams said.

"Even if we somehow stopped emitting CO2 into the atmosphere today," Dr. Williams told reporters, "the *Nature Science* study shows there would be irreversible and devastating effects on the earth's climate."

The AAGS report states that the *Nature Science* study "supports only one conclusion: limiting emissions is a wasteful and futile strategy." Instead the report urges removal of restrictions on research into technologies for controlled climate cooling.

"There are scores of such technologies on the drawing boards around the globe," said Dr. Alan Williams. "Land-based filters could remove excess CO2 from the air; high-altitude reflectors could be turned off and on to reduce solar heating; organic materials could be added to the ocean to speed up natural CO2 absorption."

Developing these so-called 'geoengineering' technologies, the AAGS report concludes would not only be more effective than enactment of emissions restrictions, but would spare consumers and businesses from the heavy economic costs associated with the regulations necessary to reduce atmospheric CO2 concentrations to 450 ppm or lower.

"Human beings have faced challenges from nature throughout history," Williams told reporters at a press conference. "We've never succumbed to those challenges - we've always overcome them with ingenuity."

"Consider today's high-yield agricultural technologies, the miracles of modern medicine, and the breathtaking feats of urban engineering," Williams stated. "Well, it's time for us to innovate our way out of another jam.

Geoengineering response to climate change. AAGS report proposes "geoengineering" after study finds that without "measures to remove gases already in the atmosphere or induce atmospheric cooling, existing CO_2 concentrations will cause irreversible environmental damage." Filters (left) could be placed in wilderness areas and that would soak up billions of tons of CO_2 from the atmosphere. Turbine-fitted vessels (right) could spray a mist to whiten clouds and make them more reflective of incoming sun light. (Credit: AAGS Report, "Beating Climate Change: Creating New Technologies, Not Restricting Old Ones.")

Liberal reminder paragraph:

Prominent environmental advocate John Herthman felt it important to add, "we will all need to make sacrifices." In a press conference following the report's publication he noted, "it's precisely because the residents of industrialized countries have for decades insisted on a standard of living that exceeds the capacities of the natural environment that we in this mess." His words echoing a widespread sentiment that climate change impacts the disadvantaged most and that advantaged countries and citizens must take a proactive role in solving the problem.

Conservative reminder paragraph:

Republican Senator Richard Shelby from Alabama, however, voiced disagreement with the study's proposal, claiming that "this [study] is just another attempt to increase already unnecessary funding for climate change, which by the way the science hasn't proven." In a press conference following the report's release Shelby added, "there are politicians who already plan on using this research to support an agenda of wasting even more American tax dollars."

Design:

Respondents were first asked to complete a 12-question battery asking to what degree they agreed with statements like "The government interferes far too much in our everyday lives" and "Our society would be better off if the distribution of wealth was more equal." These questions, taken directly from Kahan's survey, measured the hierarchical-egalitarian and individual-communitarian value sets[4]. I inserted an additional question measuring respondents' initial perception of how biased climate change scientists are.

Next, respondents were assigned one of the four versions of the geoengineering article previously described (control, liberal reminder, conservative reminder, or both). A series of time

[4] In the analysis, comparisons between respondents on different ends of the worldview spectrum means comparing respondents ±1 standard deviation on the worldview scales. For example, an egalitarian respondent would be one who measures above one standard deviation on the hierarchical-egalitarian scale.

checks were included to kick respondents who were not sufficiently engaging with the articles. Depending on what treatment respondents received, they were required to spend between 40 and 60 seconds reading the article in the first treatment level. There was a similar time check on the *Nature Science* article. Attempting to click next before spending enough time on the article kicked respondents and their responses were not included in the final data. Respondents had the option to select 'Just Text' to view the article in large, plain text format without photos (the photo captions were included).

After reading their article, respondents were asked several follow-up questions checking compliance. Among them, there was a question asking respondents to identify people who featured in the article they read. The correct answer for this question depended on which treatment they received. This question can be used to check both compliance and how closely they read the treatment paragraph.

Upon completing the compliance check, respondents were given the *Nature Science* from Kahan's survey followed by several questions measuring compliance. Finally, respondents reported how credible they found the *Nature Science* article to be and what they thought of climate change. Questions such as "how convincing was the study" and "(how much do you agree that) the scientists who did the study were biased" were combined to form a score called *study validity*. Questions such as "how much risk would you say climate change poses to human health, safety, or prosperity?" and "(how much do you agree that) human activity is causing global temperatures to rise" were combined to form a scale scored called *climate change risk*. The *study validity* and *climate change risk* scores are this study's dependent variables.

Results

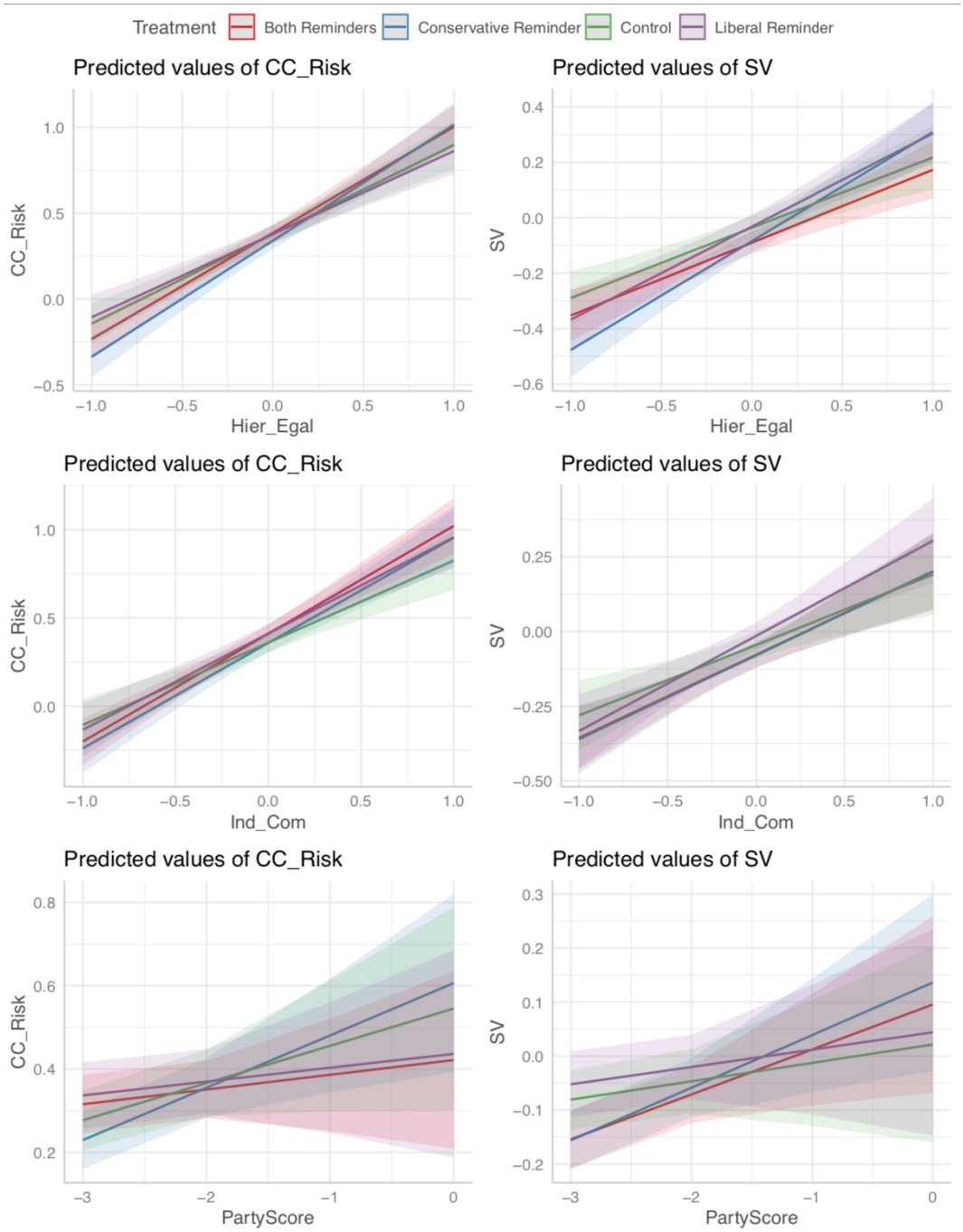
There were no main treatment effects on *study validity* or *climate change risk*. Like in Kahan et al.'s study, subjects were relatively ambivalent towards the treatments. While there was no significant difference between the treatments and the control, there was some significant variation among the treatments for *study validity*. Specifically, the difference between the liberal reminder treatment and conservative reminder treatment trended towards significance ($p = 0.061$) and the difference between the liberal reminder and both reminders was significance ($p = 0.034$). This was not the case for *climate change risk*, for which there were no significant differences between the treatments whatsoever.

Both cultural worldview scales had strong positive correlations with *study validity* and *climate change risk* ($p < 0.001$ for all). The coefficients of change were noticeably larger in the regressions of worldview scales and *climate change risk* than in the regressions of worldview scales and *study validity* (hier-egal: 0.579 vs 0.309; ind-com: 0.384 vs 0.279). Similarly, self-reported party affiliation (where a higher score indicated closer affiliation with the Republican party) correlated negatively with *study validity* ($p = 0.0005$) and *climate change* ($p < 0.001$). Also as expected, self-identified partisanship correlated strongly with hierarchy ($p < 0.001$) and individualism ($p = 0.0038$).

Figure 4 displays the graphs of *study validity (SV)* and *climate change risk (CC_Risk)* conditioned by the two worldview scales *(Hier_Egal and Ind_Com)* and partisanship *(PartyScore)*. Notice that there is extremely little variation between the treatments when conditioned for the hierarchical-egalitarian and individual-communitarian scales. There also appears to be more variation between the treatments (although not statistically significant) when conditioned for partisanship. The results did not demonstrate with significance that hypothesis

two was correct, however, the graphs in Figure 4 hint that a result might be detected with a larger sample size.

Figure 4: The Effect of Treatment Group on *Study Validity* and *Climate Change Risk* Conditioned for Worldviews and Partisanship.



Subjects at either end of the hierarchical-egalitarian spectrum reacted differently to different treatments. When assigned the conservative reminder treatment, hierarchs behaved as expected and reported lower *study validity* ($p = 0.005$) and *climate change risk* ($p = 0.003$). They did not differ meaningfully from the control in either the liberal reminder or both reminders treatments. Egalitarians, on the other hand, behaved contrary to expectations and trended towards higher *study validity* ($p = .061$). This does not support hypothesis 3a, which predicts that both hierarchical/individuals and egalitarian/communitarian respondents will report higher study validity and climate change risk in the control than in the treatment groups. However, the existence of significant treatment effects suggests that the null result still gives us meaningful information.

Like in Kahan et al.'s study, the hierarchical-egalitarian scale interacted more with treatment manipulations than the individualist-communitarian scale in this experiment. Although communitarians reported higher *study validity* and *climate change risk* across all treatments than individualists, there were no meaningful treatment effects among just communitarians or individualists.

During analysis it became clear that when asked who featured in their article, respondents were much better at recalling Republican Senator Richard Shelby (either in the conservative reminder or both treatment) than the environmentalist Alan Herthman (either in the liberal reminder of both treatment). Of the 327 respondents who received both cultural reminders, 57 recalled both, 149 recalled just Shelby, and a mere 30 recalled just Herthman (the rest failed to correctly identify any of them). Similar discrepancies were observed in the treatments containing just one reminder.

This could simply be because many respondents may have previously heard of Senator Shelby. It could also be that respondents were more attentive to information reaffirming their

position. Interesting, it turned out that reported treatment turned out to be a very strong predictor of *climate change risk*. Specifically, respondents who identified Shelby as having featured in their article reported lower *climate change risk* than respondents who answered both ($p = 0.038$) and Herthman ($p = 0.047$). This significance disappears when we examine only respondents who correctly recalled who featured in the article they read (likely due to insufficient sample size).

Analysis and Interpretation

The absence of a general treatment effect does not support hypotheses 1a or 1b, which predicted that all treatments would show reduced *study validity* and *climate change risk* and that the both treatments display the largest decrease. The charitable interpretation of this result is that the disentanglement effect was overall very durable. Even after being reminded that climate change has cultural significance, treatment group subjects continued to report similar *study validity* and *climate change risk* levels as those in the control. Assuming 1) that the geoengineering article was disentangling the respondents and 2) the treatments were sufficient reminders that climate change carries cultural baggage, this result bodes well for real life efforts to apply disentanglement.

Another interpretation is that treatments were too subtle. Given that Kahan et al. found no main treatment effect either and that my treatments were far subtler than theirs (inserted paragraphs as opposed to completely different articles), it is perhaps not a surprise that there was no general treatment effect. It could also be the case that the disentanglement effect is already so small that the potential effect of the cultural reminders is miniscule to begin with.

Not only did the treatments not report significantly lower *study validity* or *climate change risk*, but the liberal reminder group differed meaningfully from the both reminders and the conservative reminder groups. This undermines the idea that any reminder that climate change is

a culturally contested issue position should impede the disentanglement effect similarly by bolstering reliance on the culture channel. If Kahan theoretical analysis was correct—i.e. the difference between how typical and disentangled subjects perceived *study validity* and *climate change risk* was a result of disentanglement reducing reliance on the culture channel—then all treatment groups should have behaved similarly. Thus, this divergence may show that instead of increasing or reducing reliance on the culture channel, the treatments merely appealed to cultural biases differently. This begs the question, did the geoengineering article actually cause respondents to engage more objectively with scientific information in the first place or did it just momentarily bolster certain cultural predispositions? I hope that these results can inform researchers explore this question in future studies.

As suspected, worldview and political affiliation were very closely related. Recall van der Linden's concern that Kahan et al.'s geoengineering article could be actually applying more to group identity than to worldview/values. My examination of the treatment effects conditional on the hierarchical-egalitarian scale, individual-communitarian scale, and partisanship hinted at van der Linden being correct. Although the treatment effects conditioned by partisanship did not display significant at 95% confidence interval, they did appear to vary more from the control than those condition for worldview.

This interpretation is challenged by the finding that the hierarchical-egalitarian scale interacted strongly with the certain treatments for more relatively hierarchical and relatively egalitarian respondents (±1 standard deviation). Contrary to my expectation that the treatments would decrease *study validity* and *climate change risk* regardless of worldview, the liberal and conservative reminders interacted differently with hierarchical respondents than with egalitarian respondents. Specifically, egalitarians reported higher *study validity* when exposed to the liberal

reminder and hierarchical respondents reported lower *study validity* and *climate change risk* when exposed to the conservative reminder.

What does this mean for science communicators? First, it shows that not all Republicans respond to climate change information the same way. If, for example, communicators wanted to appeal to a subpopulation they knew to be particularly hierarchical in worldview, strategies that might be expected to work on egalitarian populations would likely be ineffective. Broadly stated, appealing to Republicans as a monolith will likely be less effective than creating nuanced communication strategies that appeal to certain values/worldviews.

In both Kahan et al.'s study and ours, the hierarchical-egalitarian worldview scale interacted more with the various treatments than the individualist-communitarian scale. Although the individualist-communitarian scale was a strong predictor of *study validity* and *climate change risk*, there was very little evidence of meaningful interaction with experimental manipulations. Is this dynamic generally true? That is, does the hierarchical-egalitarian worldview spectrum generally interact more with climate change communication strategies or is this just a product of our specific research instruments? Going forward, science communication researchers should prioritize inquiries, like this, which clarify how specific cultural elements can bolster real world climate change communication efforts.

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